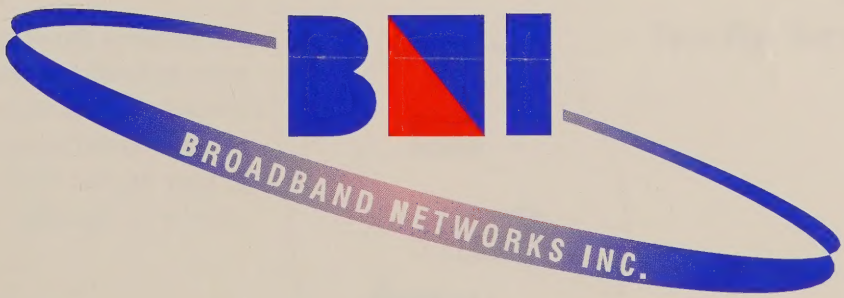
Guide to Digital Wireless MMDS Networks



BNI designs, manufactures, installs, and supports integrated digital wireless systems and provides a wide range of system planning and applications engineering services to its customers along with 24 hour a day technical support to keep your system operating at all times.

Designed to be cost effective, with high channel capacity and efficiently tailored service areas, the BNI digital wireless system provides system operators with immediate revenue and long term network expansion capability.

BNI – The future of digital wireless networks

BNI has introduced the first integrated digital solution for wireless cable operators. The BNI architecture includes everything that is required for compression, trunking, and distribution of digital signals to allow operators to create full service wireless digital networks.

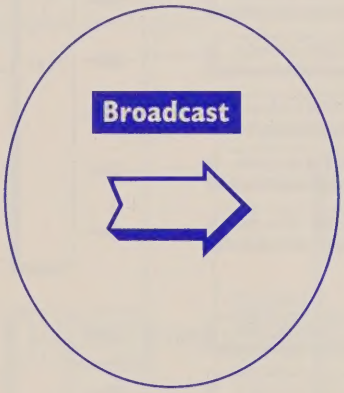
BNI offers the widest selection of digital network equipment for wireless cable operators. From MPEG 2 (Moving Pictures Experts Group) encoders to statistical multiplexers, broadband transmitters, and integrated receiver decoders — BNI is your full network integrator. All products are designed and manufactured by BNI precisely for wireless applications.

BNI offers full network design capability and can take your system from concept to completion.

Broadcast Services

The BNI system provides wide area broadcast capability for hundreds of digital channels.

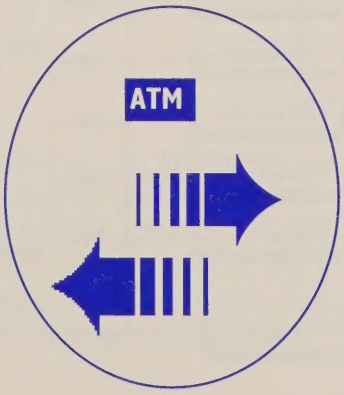
With BNI's broadband transmitter system design, system operators can add channels without adding costly transmission equipment.



Two-Way Services

BNI's small cell network architecture allows for full two-way networks that can offer real services to your customer base. From high-speed internet to teleconferencing, BNI can get your system and your customers to where they want to be.

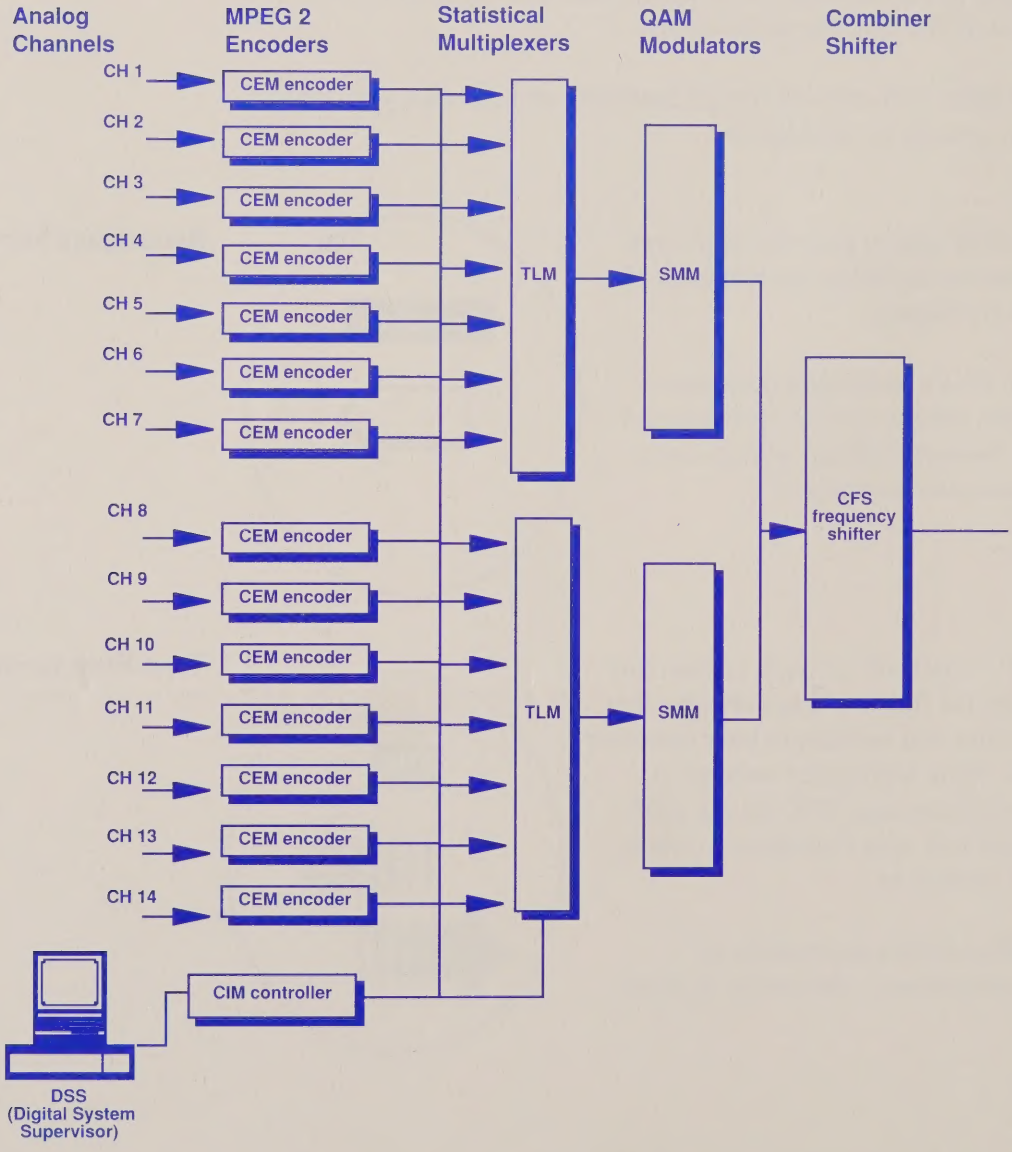
Traffic can be synchronous or asynchronous — the choice is yours.



The First Integrated Digital Wireless Solution

Employing the ISO-accepted MPEG compression standard and efficient DVB-compliant Quadrature Amplitude Modulation (QAM). the BNI system ensures an open architecture that grows with your needs.

BNI's open architecture paves the way for future services and a two-way full service communications network that can include products from different vendors, giving you strength in developing your system's capability. BNI has years of experience in the design and



manufacture of wireless networks and has developed this entirely new product family for the wireless cable industry.

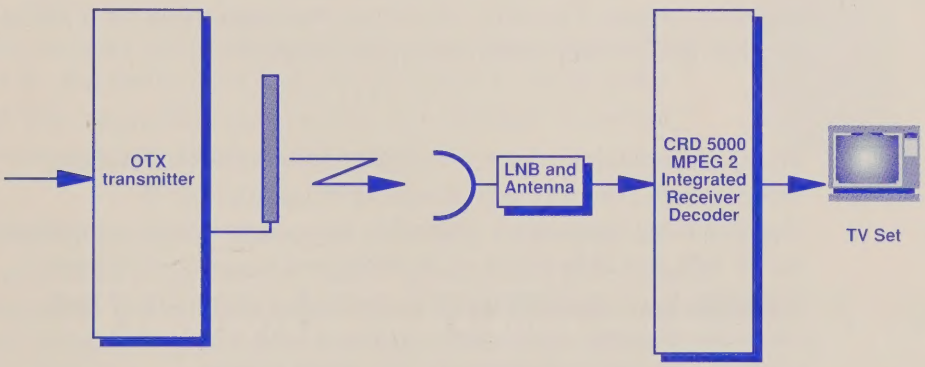
The BNI digital system allows you to provide hundreds of channels to subscribers within the allocated frequency band and to do so with digital quality and reliability.

The system's modular design allows both the compression rates and the modulation methods to be upgraded, so you can increase the number of channels without increasing the system bandwidth.

BNI System Architecture

The BNI system consists of an engineered network of products from two families.

- The Digital Signal Compression System (DSCS) product family includes all the digital elements from the analog TV channel inputs to the modulator output.
- The Digital Broadband Microwave System (DBMS) product family includes all the elements needed for signal transmission.



As illustrated, each analog TV channel is fed into an MPEG 2 compliant (Main Level @ Main Profile) Channel Encoder Module, where it is digitized and compressed. The MPEG 2 encoder produces excellent picture quality for direct-to-home service. The encoder's video output bit rate per TV channel is variable from 1 to 15 Mbps and is set by the operator on a channel-by-channel basis.

The Transport Layer Multiplexer is a statistical multiplexer that combines the outputs of up to 19 encoders into one MPEG 2 packetized bit stream, with a maximum output bit rate of 155 Mbps. The encoding rate can be changed "on the fly" to provide a more efficient use of the available spectrum.

DVB-Compliant QAM

The multiplexer output is connected to a modulator which implements Quadrature Amplitude Modulation (QAM). All BNI modulators are DVB-compliant and support 16, 64, and 256 QAM constellations. The modulator receives the digital input, attaches additional bits to provide error detection and correction, and then modulates the digital stream onto an RF carrier, typically at VHF frequencies.

Central Digital System Control

The encoding process is controlled through the Chassis Interface Module (CIM) and the Digital System Supervisor (DSS). The DSS is a BNI-developed software program which is accessed through an MS-DOS compatible personal computer. The DSS software provides the system installation, encoder configuration, and monitoring functions.

The CIM circuit card provides the interface to all elements of the encoding system. The DSCS system is packaged using the VMEbus standard and 19-inch communications cabinets.

Flexible Frequency Allocation

The QAM modulator output is connected to a carrier frequency shifter which allocates each carrier to its appropriate IF (Intermediate Frequency). Typically, the system operator specifies the IF, which is dependent on an individual system's regulatory licensing. Each modulated carrier contains a minimum of four television channels and, when combined with other carriers, requires only one transmitter for the entire system.

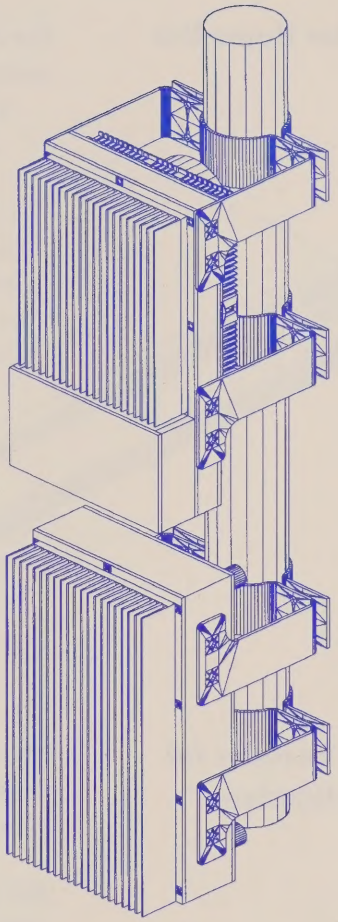
Transmitting the Signal

The OTX transmitter provides additional gain for the signal. The transmitter can be mounted on the tower as close to the antenna as is practical or can be rack-mounted indoors, depending on your requirements. The antenna can be horizontally or vertically polarized, using various antenna radiation patterns.

Different transmitters are used to provide customized coverage areas based on subscriber concentration pockets, topography of the service area, and your individual network requirements. Independent of the channel count, only one transmitter is ever needed.

The BNI microwave product family is designed to provide trouble-free service in unforgiving outdoor conditions. Compact size and low loss mounting provide for efficient and inexpensive installation. BNI transmitters upconvert the modulated carriers to microwave frequency using a solid state amplifier upconverter process. No matter how many channels are being transmitted, a system only ever needs one broadband transmitter per site.

BNI repeaters and receivers allow you to create a true network and to effectively serve multiple areas from a single head-end.The transmitters and repeaters are available in multiple power ratings to match each application.



OTX 2510 Outdoor Transmitter.

All BNI transmitters and repeaters contain a full suite of remote monitoring tools for troubleshooting and performance evaluation. You can remotely monitor an installation from a central DSS location. Again, this is part of BNI's full service network approach.

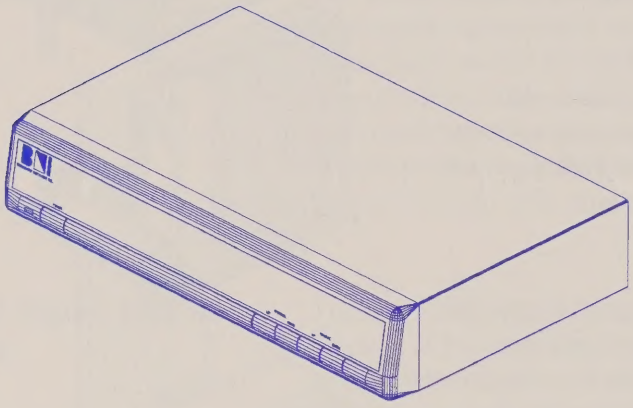
Customer Premise Transceiver

BNI has designed the first MMDS transceiver for two-way applications. This small unit provides 10 Mbps channel access for subscribers. This capability opens the door for full service networks that offer a wide variety of services.

Receiving the Signal

Set-Top for Home Use

For direct-to-home (DTH) distribution systems, each subscriber uses an antenna, a low noise block downconverter (LNB) and BNI's CRD 5000 set-top decoder. The antenna and LNB are standard equipment, with many manufacturers offering newer designs that increase the receive system phase linearity. The LNB output, at VHF levels, is input to the CRD MPEG 2 set-top decoder.



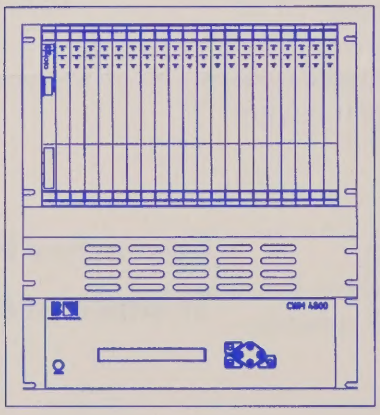
The set-tops offer the customer a single channel at a time, and can be connected into the customer's VCR or television.

CRD 5000 — BNI's MPEG 2 Set-Top Decoder.

Receiver Decoder for MDU Applications

BNI offers both trunking and distribution for a Multiple Dwellings Units (MDU). At the MDU, a microwave receiver downconverts the microwave signals to the IF level.

The IF signal is input to a Broadband Receiver Decoder which converts it to a digital data stream. The digital data stream is decoded and converted to the original analog format.



The BRD is a multi-channel studio quality MPEG 2 demultiplexer and decoder. The BRD outputs all the TV channels simultaneously, with each channel output consisting of a single composite video and two stereo audio signals at baseband levels.

This system is an ideal way to provide service to apartments and other high density sites.

BRD 4800 — Broadband Receiver Decoder for MDU Use

System Bandwidth, RF Spectrum Utilization, and Modulation Methods

The number of TV channels that can be placed within the available RF band is a function of the signal compression level, the type of forward error correction that is used, and the modulation system spectral efficiency.

To calculate the bandwidth required for a specific system, you add the audio bit rate (typically 384 kbps per channel), the video bit rate (typically 4 to 8 Mbps per channel), the MPEG transport overhead (3%), and the Forward-Error Correction overhead (typically 12.5%). For a system operating at a 4 Mbps video rate, the total digital bandwidth for a single TV channel is 4.384 X 1.03 X 1.125 = 5.08 Mbps per TV channel. This is the Digital Channel Rate.

This data is modulated onto an IF carrier at a particular bits/sec/Hz rate. For example, the spectral efficiency of a typical 16-QAM modulator is 3.5 bits/sec/Hz and so 1.4 MHz of bandwidth is required for one TV channel at a 4 Mbps digital channel rate.

If 64-QAM modulation is used, typical spectral efficiencies are 5 bits/sec/Hz, and so 1 MHz bandwidth is required for a single TV channel.

The following table illustrates the frequency bandwidth that is required to transport 20, 31, 60, and 100 NTSC channels for various system configurations. For a 16-QAM system with the encoding rate of 4 Mbps per TV channel, 87 MHz of bandwidth is required to support 60 NTSC TV channels.

Modulation Method and Video Encoding Rate	MHz/Digital Channel	Number of NTSC TV Channels			
		20	31	60	100
16 QAM, 8 Mbps	2.78	56 MHz	86 MHz	167 MHz	278 MHz
16 QAM, 4 Mbps	1.45	29 MHz	45 MHz	87 MHz	145 MHz
64 QAM, 8 Mbps	1.94	39 MHz	60 MHz	117 MHz	194 MHz
64 QAM, 4 Mbps	1.02	20 MHz	31 MHz	61 MHz	102 MHz

Digital wireless system total bandwidth requirements.

Forward Error Correction

Highly reliable digital signal delivery is obtained through the use of Forward Error Correction (FEC) techniques such as Reed-Solomon and convolutional coding. The FEC hardware is located within the modulator, and within the MPEG 2 set-top (for MMDS applications) or the BRD receiver decoder (for MDU applications). FEC coding adds information at the transmit site that allows the receive site hardware to detect and to correct errors.

The BNI system incorporates MPEG standard Reed-Solomon (RS) FEC, which adds 16 bytes on the end of the 188-byte MPEG 2 packet for the RS (204, 188) coding method. Convolution coding is available at rates of 7/8 and 3/4 for even greater error correction and system reliability. The 7/8 rate adds 1 byte for each 7 input bytes and the 3/4 rate adds 1 byte for each 3 input bytes. The RS coding provides protection against small numbers of bit errors and the convolutional codes provide increased protection against burst errors.

All BNI systems include additional protection through interleaving and energy-dispersal algorithms. For trunking and MDU applications, alternative RS coding rates are available. The type and amount of FEC that is used is system-specific and is specified during system planning.

The advantage of FEC is that it allows a better picture to be achieved at a lower received signal level and consequently allows for larger service areas and higher fade margins.

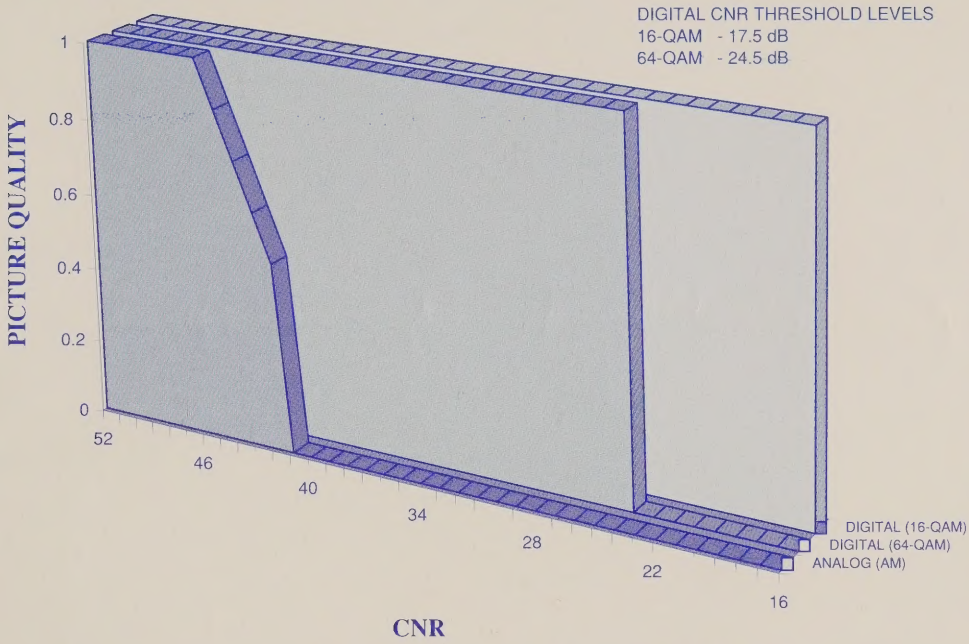
Picture Quality

In a digital wireless system, there are two primary issues which affect picture quality:

- the compression rate of the channel encoder
- the signal threshold of the receiver setup

BNI's digital compression encoders digitize an analog video signal at 210 Mbps and compress it to between 1.5 and 15 Mbps. At 1.5 to 4 Mbps MPEG video data rates, the video is comparable in quality to a consumer grade VCR. Data rates above 4 Mbps deliver studio quality video and at about 8 Mbps approach broadcast quality. Typically, video data rates of 4 Mbps provide excellent signal quality for most direct-to-home applications.

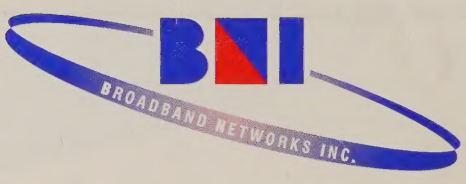
PICTURE QUALITY COMPARISON



Picture Quality vs. Signal-to-Noise Ratio

Due to the nature of multi-level QAM modulation, the picture quality at the receive end is resistant to the Signal-to-Noise Ratio fluctuations. Digital picture artifacts become visible as the SNR decreases to approximately 1.5 to 2.5 dB above the receiver signal threshold. If the signal level crosses the threshold, the picture is lost and when the signal level goes above the threshold again, the picture is recovered very suddenly.

This behavior is illustrated above, and is referred to as the *digital cliff*. Though analog NTSC video channels begin to degrade at Carrier-to-Noise Ratio of 45 dB, the digital signal continues to be received with no change in picture quality to levels of 24.5 dB. This improved threshold allows a digital wireless system to be designed for larger service areas, for reduced transmitter power, for improved service quality, or for a combination of all three.



Broadband Networks Inc.
37 Stevenson Road
Winnipeg, Manitoba
Canada R3H 0H9

Telephone: (204) 982-8480
FAX: (204) 982-8487

Call toll-free in the USA and Canada 1-800-822-6355.